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Materiel Test Procedure 4-2-703\*  
Aberdeen Proving Ground

U. S. ARMY TEST AND EVALUATION COMMAND  
MATERIEL TEST PROCEDURE

COMMON ENGINEERING TEST PROCEDURE

PROPELLANT ACTUATED DEVICES

1. OBJECTIVE

The objective of this MTP is to detail test methods for the evaluation of propellant actuated devices.

2. BACKGROUND

Propellant actuated devices (PAD's) are compact self-contained packages which utilize the energy made available by the burning of propellant charges to do useful work. These devices can be mechanically, gas, or electrically triggered. Typical configurations and functions include closed and vented vessels to supply the impulse required to perform a desired action against a variety of resisting forces; various configurations for the inflation and/or rigidization of collapsible structures; and vented vessel configurations for the pressurizing and pumping of liquid systems.

The devices are installed in aerospace vehicles (aircraft, missiles, and spacecraft), ground vehicles, and combat equipment. They include canopy removers, seat and capsule ejection catapults, bomb and stores ejectors, beacon ejectors, drag chute ejectors, engine starter cartridges, cutters, disconnects, gas generators, thrusters, electric ignition elements, stud drivers, lap belt tighteners, seat-man separators, fire extinguisher cartridges, explosive bolts, life raft inflators, pontoon inflators, and paraglider inflators.

Appendix A lists the types and characteristics of PAD's.

3. REQUIRED EQUIPMENT

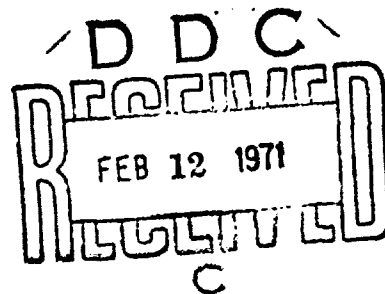
- a. X-Ray Facility
- b. Tensile Testing Machine
- c. Torque wrenches (having a capacity of more than 400 inch-pounds)
- d. Temperature Conditioning Chamber
- e. Ovens
- f. Metal Plate
- g. Vibration Testing Equipment
- h. Sand, Dust, and Salt Spray Equipment
- i. Altitude Chamber
- j. Movable Carriages
- k. Variable Resistive Load Devices
- l. Horizontal and Vertical Tracks
- m. Toxic Air Sampling Device

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- n. Exhaust Gas Sampling Device
- o. Recorders and Timing Devices
- p. Displacement Pickups (Mechanical, Optical, and Magnetic)
- q. Load Cells
- r. Strain Gages
- s. Accelerometers
- t. High Speed Motion Picture Camera
- u. Motion Picture Film with Timing Marks

4.

REFERENCES

- A. AMCP 706-270, Research and Development of Material - Engineer Design Handbook, Propellant Actuated Devices.
- B. MIL-D-21625C (WP), Design and Evaluation of Cartridges for Cartridge Actuated Devices.
- C. MIL-D-23615 (WP), Design and Evaluation of Cartridge Actuated Devices.
- D. MIL-STD-810A (USAF), Environmental Test Methods for Aerospace and Ground Equipment.
- E. MIL-C-25918 (WP), Cartridge Actuated Devices, Aircraft Crew Emergency Escape, General Specification for.
- F. AR 705-15, Operation of Materiel Under Extreme Conditions of Environment.

5.

SCOPE

5.1

SUMMARY

The following tests shall be conducted:

- a. Structural Test - determination of the structural soundness.
- b. Torque Test - determination of the minimum breakaway torque for threaded joints.
- c. Locked Shut Test - determination of safety and strength of a completely restrained device.
- d. No-load Test - determination of the mechanical integrity when fired under no-load conditions.
- e. Cook-off Test - determination of temperature at which a PAD will self-fire.
- f. Extreme temperature Tests
- g. Drop Tests
- h. Vibration Tests
- i. Sand and Dust Tests
- j. Salt Spray Tests
- k. High Altitude Tests

5.2

LIMITATIONS

The procedure given in this MTP should be used for testing PAD's unless other test directives, SDR's, or QMR's list conditions that would make

a certain test meaningless.

6. PROCEDURES

6.1 PREPARATION FOR TEST

6.1.1 Pre-test Operation

Record the following for each test item tested:

- a. Type, serial number and manufacturer
- b. Weight
- c. Envelope dimensions
- d. Center of gravity

6.1.2 Instrumentation and Equipment Installation

Prior to performing functioning tests the following equipment and instrumentation shall be prepared and installed as applicable.

a. Equipment

- 1) Movable carriages
- 2) Variable resistive load devices
- 3) Horizontal or vertical tracks
- 4) Toxic air sampling devices
- 5) Exhaust gas sampling devices
- 6) High speed motion picture camera and film

b. Instrumentation

- 1) Displacement pickups - mechanical, optical or magnetic (capable of measuring from inches per second to hundreds of feet per second).
- 2) Accelerometers (capable of measuring from fractions of a g to tens of thousands of g.)
- 3) Load cells (capable of measuring thrust for fractions of a pound to tens of thousands of pounds.)
- 4) Strain gages (capable of measuring pressure from 0.1 to 25,000 psi.)
- 5) Appropriate recorders and timing devices.

6.2 TEST CONDUCT

6.2.1 Structural Test

- a. Obtain a minimum of six PADs for testing
- b. Identify and X-ray each PAD
- c. Subject at least one PAD to the maximum specified tension load, while in a tensile test machine at the applicable high temperature of Table A-II,

Appendix A.

- d. X-ray the tested PAD to determine the effects, if any, of the tension test.
- e. Subject at least one PAD to the maximum specified compression load, while in a tensile test machine, at the applicable high temperature of Table A-II, Appendix A.
- f. X-ray the tested PAD to determine the effects, if any, of the compression test.
- g. Repeat steps c through f at a temperature of 70°F.
- h. Repeat steps c through g at the applicable low temperature of Table A-II, Appendix A.

6.2.2 Torque Test

- a. Obtain a minimum of two PADs for testing
- b. Determine that the torque required for loosening the various threaded joints meets specifications as follows:
  - 1) For threaded joints that can be loosened by handling, vibration, shipment, etc. apply a torque of 200 inch-pounds. Indicate if joint loosens.
  - 2) For joints involved in mounting the PAD or the attachment of pressure hoses apply a torque of 400 inch-pounds. Indicate if joint loosens.

6.2.3 Locked Shut Test

- a. Obtain a minimum of six PADS for testing
- b. Subject three sample PADs to the transportation vibration and shock test of MIL-STD-810A, Method 514-1, Equipment Class 6 (reference 4D) at the high temperature of paragraph 6.2.1.
- c. Restrain the PADs, at the temperature of step b to prevent movement.
- d. Fire the test items and record the following:
  - 1) Pressure versus time
  - 2) Absence of a mechanical explosion
- e. Repeat steps b, c, and d at the low temperature of paragraph 6.2.1.

6.2.4 No-load Test

- a. Obtain a minimum of two nonseparating stroking PAD's for testing the test items.
- b. Fire under no-load conditions and observe mechanical integrity.
- c. Record the functioning with a high speed camera and timed film.

6.2.5 Cook-off Test

- a. Place a minimum of three PAD's in an oven and cook at an estimated temperature that will produce cook-off in one hour.

- b. If cook-off does not occur, increase the oven temperature by 25°F and cook the test items for one hour.
- c. Repeat step b in increments of 25°F until cook-off occurs.
- d. Record cook-off temperature

#### 6.2.6 Extreme Temperature Tests

- a. Obtain a minimum of four PADs for testing.
- b. Identify and x-ray each PAD.
- c. Condition one-half the test items at the high temperature of paragraph 6.2.1 in a temperature chamber for a minimum of 24 hours.
- d. X-ray each test PAD and record any propellant structure damage.
- e. Fire the test items

NOTE: If, for safety reasons, the test items cannot be fired within the temperature chamber, fire them within 5 minutes after removal to ambient temperature.

- f. Measure and record the following as applicable:

- 1) Thrust versus time
- 2) Pressure versus time
- 3) Displacement versus time
- 4) Velocity versus time
- 5) Acceleration versus time

- g. Repeat steps c through f at the low temperature of paragraph 6.2.1.

#### 6.2.7 Drop Tests

##### 6.2.7.1 Six Foot Drop Test

- a. Obtain a sample containing a minimum of 18 PAD's
- b. Drop a minimum of two samples nose up on a hard, smooth plate (preferably a metal plate) from a height of six feet.
- c. X-ray each test item for structural damage
- d. Fire the test items at normal temperature, all must function
- e. Measure and record:

- 1) Thrust versus time
- 2) Pressure versus time
- 3) Displacement versus time
- 4) Velocity versus time
- 5) Acceleration versus time

- f. Record functionings with a high speed camera and timed film.

- g. Repeat steps (c) through (f) above with a minimum of two test items dropped nose down.

- h. Repeat steps (c) through (f) above with a minimum of two test items dropped horizontally.

i. Repeat steps (c) through (h) above at the high temperature used in paragraph 6.2.1.

j. Repeat steps (c) through (h) above at the low temperature used in paragraph 6.2.1.

#### 6.2.7.2 Forty Foot Drop Test

a. Obtain a sample containing a minimum of nine PAD's

b. Drop a minimum of 1 PAD nose up from a height of forty feet and insure that it does not explode upon impact or become unsafe for disposal

c. Repeat step (b) above with a minimum of one test item nose down.

d. Repeat step (b) above with a minimum of one test item horizontal.

e. Repeat steps (b) through (d) above at the high temperature used in paragraph 6.2.1.

f. Repeat steps (b) through (d) above at the low temperature used in paragraph 6.2.1.

#### 6.2.8 Vibration Test

a. Obtain a sample containing a minimum of 4 PAD's

b. Conduct a vibration test on each sample as described in the applicable parts of MIL-STD-810A, Method 514.1 (reference 4D)

c. At the conclusion of the test, tear down one-half of the sample and examine for any damage.

d. Function the remaining half of the sample at normal temperature to insure normal operation.

e. Measure and record:

- 1) Thrust versus time
- 2) Pressure versus time
- 3) Displacement versus time
- 4) Velocity versus time
- 5) Acceleration versus time

f. Record the functioning with a high-speed camera and timed film.

#### 6.2.9 Sand and Dust Test

a. Obtain a sample containing a minimum of two PAD's.

b. Conduct a sand and dust test as described in MIL-STD-810A, Method 510. (reference 4D)

c. Examine the exteriors of the sample

d. X-ray each device for structural damage

e. Function the sample at normal temperature to assure normal operation.

f. Measure and record:

- 1) Thrust versus time
- 2) Pressure versus time
- 3) Displacement versus time

- 4) Velocity versus time
- 5) Acceleration versus time

g. Record the functioning with a high speed camera and timed film.

#### 6.2.10 Salt Spray Test

- a. Obtain a sample containing a minimum of two PAD's
- b. Conduct a salt spray test as described in MIL-STD-810A, Method 509.
- c. Examine the exteriors of the sample
- d. X-ray each device for structural damage
- e. Function the sample at normal temperature to assure normal operation.
- f. Measure and record:
  - 1) Thrust versus time
  - 2) Pressure versus time
  - 3) Displacement versus time
  - 4) Velocity versus time
  - 5) Acceleration versus time

g. Record the functioning with a high speed camera and timed film.

#### 6.2.11 High Altitude Test

- a. Obtain a sample containing a minimum of two PAD's.
- b. Condition the sample in a temperature - altitude chamber at the low temperature of paragraph 6.2.1.
- c. Reduce the chamber pressure to 0.82 inches mercury (80,000 ft)
- d. Condition the sample at the above temperature and pressure for one hour.
- e. Remove the sample and x-ray each device.
- f. Function them and record:
  - 1) Thrust versus time
  - 2) Pressure versus time
  - 3) Displacement versus time
  - 4) Velocity versus time
  - 5) Acceleration versus time

g. Record the functioning with a high speed camera and timed film.

### 6.3 TEST DATA

#### 6.3.1 Pre-Test Operations

Record the following for each PAD tested:

- a. Type, serial number, manufacturer
- b. Test PAD number (1, 10 etc.)

- c. Weight in pounds
- d. Envelope dimensions in inches
- e. Center of gravity in inches from lower right hand corner of PAD

#### 6.3.2 Structural Test

Record the following for each PAD tested:

- a. Maximum tension loads at high temperature
- b. Maximum compression loads at high temperature
- c. Maximum tension loads at normal temperature
- d. Maximum compression loads at normal temperature
- e. Maximum tension loads at low temperature
- f. Maximum compression loads at low temperature
- g. Results of comparison with design parameters.
- h. Retain post test X-rays and compare to pre-test x-rays

#### 6.3.3 Torque Test

- a. Record results of 200 in-lb. breakaway torque test on threaded joints that can be loosened by handling, vibration, shipping, etc.
- b. Record results of 400 in-lb. breakaway torque test on joints involved with mounting of the device or attachment of pressure hoses.

#### 6.3.4 Locked-Shut Test

Record the following for each PAD:

- a. Test temperature in °F
- b. Test PAD test number (1, 2, or 3)
- c. Maximum pressure obtained
- d. Presence or absence of a mechanical explosion

#### 6.3.5 No-load Test

- a. Record the following:

- 1) Test PAD test number (1 or 2)
- 2) Integrity of the PAD (separation, no separation, partial separation)

- b. Retain motion pictures of the functioning

#### 6.3.6 Cook-off Test

Record the following:

- a. Minimum cook-off temperature in °F
- b. Number of samples fired at cook-off temperature



6.3.7 Extreme Temperature Test Data

- a. Retain and compare post-conditioning x-rays with pre-test x-rays
- b. Record the following:
  - 1) Test temperature
  - 2) Thrust versus time
  - 3) Pressure versus time
  - 4) Displacement versus time
  - 5) Velocity versus time
  - 6) Acceleration versus time
- c. Retain motion picture of functioning

6.3.8 Drop Test Data

- a. Record temperature at which item was drop tested
- b. Record the following observations:
  - 1) Functioning after dropped nose up
  - 2) Functioning after dropped nose down
  - 3) Functioning after dropped horizontally
- c. Retain post-test x-rays and compare to pre-test x-rays
- d. Record:
  - 1) Thrust versus time
  - 2) Pressure versus time
  - 3) Displacement versus time
  - 4) Velocity versus time
  - 5) Acceleration versus time
- e. Retain motion pictures of functioning
- f. Indicate:

Whether PAD's will

  - 1) Fire
  - 2) Not fire
  - 3) Be unsafe for disposal on impact from 40 foot drop in positions of:
    - a) Nose up
    - b) Nose down
    - c) Horizontally

6.3.9 Vibration Test Data

- a. Record data collected as described in the applicable parts of MIL-STD-810A, Method 514.1 (reference 4D)

- b. Record results of examination for damage
- c. Record:

- 1) Thrust versus time
- 2) Pressure versus time
- 3) Displacement versus time
- 4) Velocity versus time
- 5) Acceleration versus time

- d. Retain motion pictures of functioning

#### 6.3.10 Sand and Dust Test Data

- a. Record data collected as described in the applicable parts of MIL-STD-810A, Method 510 (reference 4D)
- b. Record results of external examination
- c. Retain and compare post-test x-rays with pre-test x-rays
- d. Record:

- 1) Thrust versus time
- 2) Pressure versus time
- 3) Displacement versus time
- 4) Velocity versus time
- 5) Acceleration versus time

- e. Retain motion pictures of functioning

#### 6.3.11 Salt Spray Test Data

- a. Record data collected as described in the applicable parts of MIL-STD-810A, Method 509.
- b. Record results of external examinations
- c. Retain post-test x-rays and compare to pre-test x-rays
- d. Record:

- 1) Thrust versus time
- 2) Pressure versus time
- 3) Displacement versus time
- 4) Velocity versus time
- 5) Acceleration versus time

- e. Retain motion pictures of functioning

#### 6.3.12 High Altitude Test Data

- a. Record conditioning temperature
- b. Retain post-conditioning x-rays and compare to pre-test x-rays
- c. Record:

- 1) Thrust versus time

- 2) Pressure versus time
- 3) Displacement versus time
- 4) Velocity versus time
- 5) Acceleration versus time

d. Retain motion picture of functioning

#### 6.4 DATA REDUCTION AND PRESENTATION

Plot the following data for each temperature and condition of the appropriate tests:

- a. Thrust versus time, in pounds and seconds
  - b. Pressure versus time, in psi and seconds
  - c. Displacement versus time, in inches and seconds
  - d. Velocity versus time, in inches/second and seconds
  - e. Acceleration versus time, in inches/second/second and seconds
- and determine rate of change for the acceleration.

Compare these graphs to design limitations.

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## APPENDIX "A"

### PROPELLANT ACTUATED DEVICES (PAD's) - TYPES AND CHARACTERISTICS

1. TYPES - PAD's can be divided into three categories: gas - generating devices, stroking devices, and special purpose devices.

a. Gas-Generating Devices--These may be either short-or long-duration generators.

- (1) Short-Duration Generator Type--Usually called initiators, these devices are used to provide high pressure gas for less than 1 second for operation of the firing mechanisms of other PAD's.
- (2) Long-Duration Generator Type--These supply a gas flow for several minutes to spin turbines and operate pumps.

b. Stroking Devices--Stroking devices are also of two types: separating and nonseparating

- (1) Separating stroking devices include catapults and canopy removers and consist of telescoping tubes attached at one end to a fixed object, e.g., pilot seat. Initiation of the device produces gas pressure that rapidly moves the tubes apart, propelling the seat away.
- (2) Nonseparating stroking devices, either retracting or expanding such as a seat positioner thruster, produce their thrust over only a limited travel, then stop and lock in that position without any separation of the piston from the cylinder.

c. Special Purpose Devices--These include cable cutters, reefing line cutters, parachute releases, external stores and bomb releases, and electric ignition elements.

## 2. CHARACTERISTICS

a. G-Load Factor

Since many PAD's are intended to be used to effect the escape of humans, one of the prime limiting values of PAD's is the g load that the human body can safely endure. From numerous tests, the limiting values shown in Table A-I (source: Ref. 4A) have been developed and are generally accepted by the Department of Defense.

b. Temperature Parameters

Temperature also plays a very important part in the design and testing of PAD's, and Table A-II, based on References 4C, E, and F, shows the different limits used by the military services. These temperature values should be used during testing according to the service customer and the applicable specification.

c. Shelf Life

The usual period selected for satisfactory shelf or storage life is 3 to 5 years, although some items, when refurbished with new cartridges and seals, have exceeded that limit.

Table A-I. Physiological Limitations for Personnel Ejection

Direction of Ejection	Maximum Acceleration (g)	Maximum Rate of Change of Acceleration (g/sec)
Upward	20	250
Downward	12	125
Rearward (Seat Positioning)	6	60

Table A-II. PAD Temperature Limits (°F)

Reference Level	Army	Navy	Air Force
High Temperature	+155	+225	+200
Normal Temperature	+70	+70	+70
Low Temperature	-65	-80	-65